

## THE WEATHER AND CIRCULATION OF JUNE 1961

### A Hot, Dry Month in the West

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#### 1. RECENT MONTHLY TRENDS

From March 1961 thru June 1961 there was a noticeable trend in the monthly weather anomalies and circulation over the United States. Temperatures in the eastern half of the United States tended to become progressively cooler than normal while temperatures in the western half of the country continued a warming trend. At the same time, there was a gradual shift in the area of heavier than normal precipitation from northern and eastern portions to the Southern States and a noticeable tendency toward drought conditions in parts of the West.

A corresponding trend was apparent in the circulation in the mid-troposphere. Comparison of successive monthly mean 700-mb. charts for March through June shows the gradual displacement westward of a long-wave trough from the western Atlantic at the beginning of the period to the Ohio Valley by June. There were other areas in which apparent retrograde motion of major systems occurred, but in none was it so pronounced or so important to the weather in the United States.

#### 2. MONTHLY MEAN CIRCULATION

The planetary wave pattern at 700 mb. in June 1961 (fig. 1) consisted of well-defined trough and ridge systems from the western Pacific eastward to Eurasia. While this is shown by the height contours alone, it is better indicated by the height departures from normal (dotted lines in fig. 1).

In the Atlantic the circulation was characterized by westerlies that averaged considerably faster than normal in a jet maximum that extended from Newfoundland to the United Kingdom. The strong westerlies resulted from the moderately deep Icelandic Low in phase with a strong ridge in the Atlantic. The primary Icelandic Low was 310 feet deeper than normal and was displaced considerably eastward to the Norwegian Sea from its normal position near Baffin Island [1].

The Aleutian Low was similarly displaced. Its normal position in June [1] is in the Bering Sea, and it is usually accompanied by a broad cyclonic flow in the central Pacific north of 30° N. The observed flow (fig. 1) shows that the deepening trough in eastern Asia and amplifica-

tion in mid-Pacific contributed to the anomalous position of the Aleutian Low in the Gulf of Alaska. Deepening of the trough in the Gulf of Alaska was probably assisted by local baroclinic processes, suggested by the distribution of monthly mean 1000-700-mb. thickness (fig. 2), as well as by barotropic transport of vorticity from upstream.

Growth of the ridge in the central Pacific was a great change from May (see fig. 1 of [2]) when a trough was located in this area. Heights at 700 mb. increased as much as 400 ft. from May to June in the western Aleutians as the trough was replaced by a strong ridge in June.

Over North America the Canadian portion of the ridge in the West was somewhat farther east and generally 100 feet or more stronger than normal. Its companion trough downstream was west of its normal position and a little deeper than normal. This shortening of the half wavelength between the ridge and the trough resulted in a vigorous northerly component of the height anomaly field from northeastern Canada to Mexico.

There were pronounced changes in the circulation at 700 mb. from the first half of June (fig. 3A) to the last half of the month (fig. 3B). Elements of the circulation over and near North America for June 1-15 included a continental ridge and two major troughs, one in the Gulf of Alaska and the other in eastern Canada, oriented in a modified omega pattern. Flow over the United States was quite weak except along the northern border. These features are shown clearly by the contours of height and height anomaly in figure 3A.

From the first half to the last half of the month the circulation was characterized by retrogression and general flattening of the pattern at higher latitudes over North America (fig. 3). This was associated with weakening of the Low in the Gulf of Alaska. At the same time heights increased in western United States as much as 200 ft. over the Great Basin. Meanwhile, the trough in eastern North America retrograded to the Ohio Valley and joined with the trough that moved eastward from Baja California.

In summary, June was a month of relatively low index circulation over the United States. This was associated not with blocking as was May, but with a strong meridional flow that was responsible for unseasonable extremes of temperature in many parts of the country.

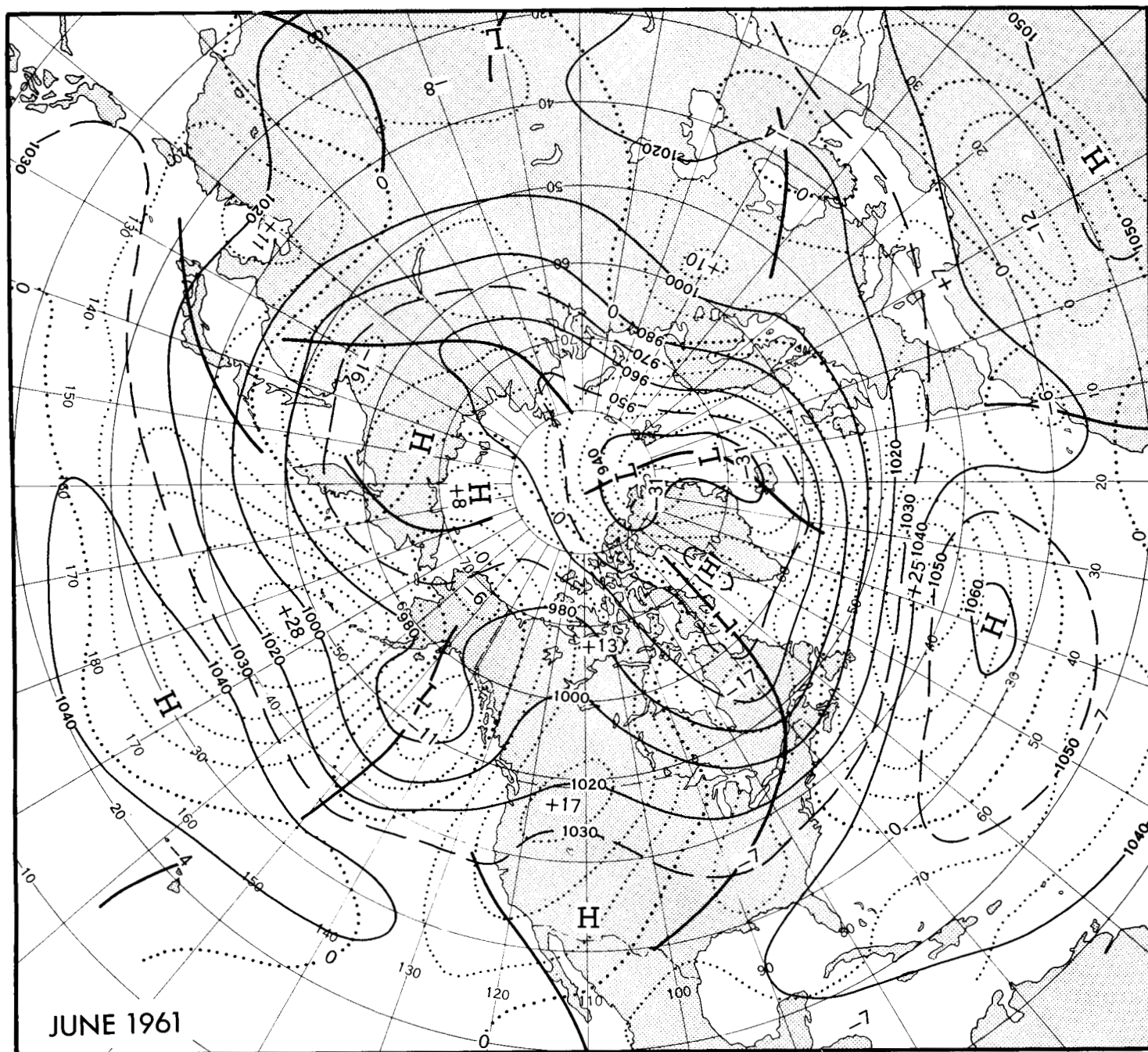


FIGURE 1.—Mean 700-mb. contours (solid) in tens of feet, and departures from normal (dotted) in 50-ft. intervals, for June 1961. The meridional nature of the height anomaly field was indicative of the low index condition over North America and the Pacific.

### 3. WEATHER RELATED TO THE CIRCULATION TEMPERATURE

Hot, dry weather in the West was associated with many new temperature records principally in Montana, California, and Oregon, while unusually cool conditions prevailed over much of the East.

Temperatures in June (fig. 4) averaged about  $2^{\circ}$  to  $4^{\circ}$  F. cooler than normal from the Southern Plains to the Mid-Atlantic States and from the Lower Great Lakes to the

Gulf of Mexico. This area was dominated by below normal heights and cyclonically curved contours on the monthly mean 700-mb. chart (fig. 1). The strong ridge in western North America steered numerous anticyclones southward from northern Canada (Chart IX of [3]) to the Northern Plains then southeastward across the Middle Atlantic States in a slightly confluent zone. A secondary track of Highs extended from western Hudson Bay to southern Quebec. In both instances daily anticyclones

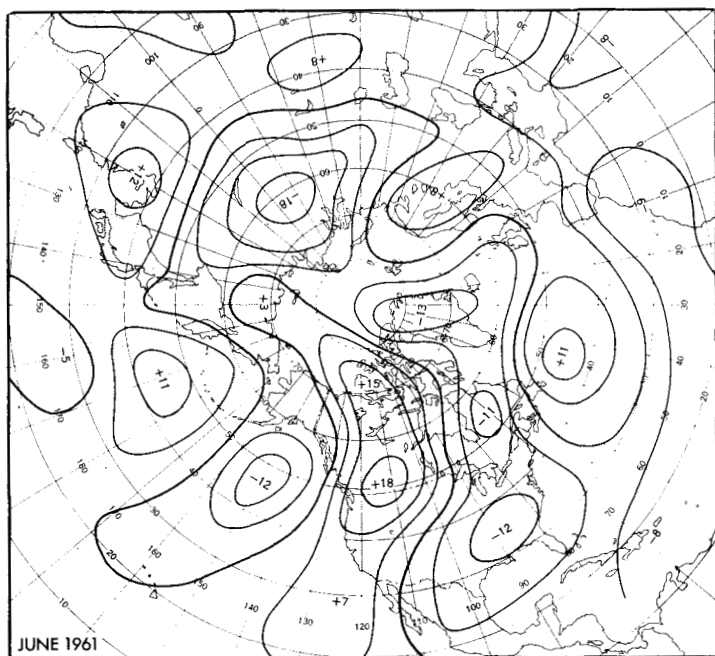


FIGURE 2.—Mean thickness (1000–700 mb.) departure from normal (isopleth interval 50 ft.) for June 1961. Cool air masses dominated the East and subsiding air warmed the West.

bypassed the Great Lakes, a very atypical occurrence in June [4].

The average thickness from 700 to 1000 mb. (fig. 2) was below normal along an axis from Labrador to the Gulf of Mexico, generally coincident with the area of below normal surface temperatures (fig. 4). Few records were established in the East beyond several new daily minimum temperatures. At Norfolk, Va., a new all-time minimum for June of  $48^{\circ}\text{F.}$  was recorded on the 17th; record low monthly mean temperatures were reported at Louisville, Ky. ( $68.9^{\circ}\text{F.}$ ) and Vicksburg, Miss. ( $75.1^{\circ}\text{F.}$ ), and the coldest June since 1903 was reported at Shreveport, La.

In contrast to the East, temperatures were exceptionally warm in the West. A large area was  $6^{\circ}$ – $10^{\circ}\text{F.}$  warmer than normal (fig. 4). This region was located under the upper level ridge where subsidence was widespread and where heights exceeded normal by as much as 170 ft. (fig. 1). Many areas in the West reported heat waves of varying duration, but one of the most intense was at

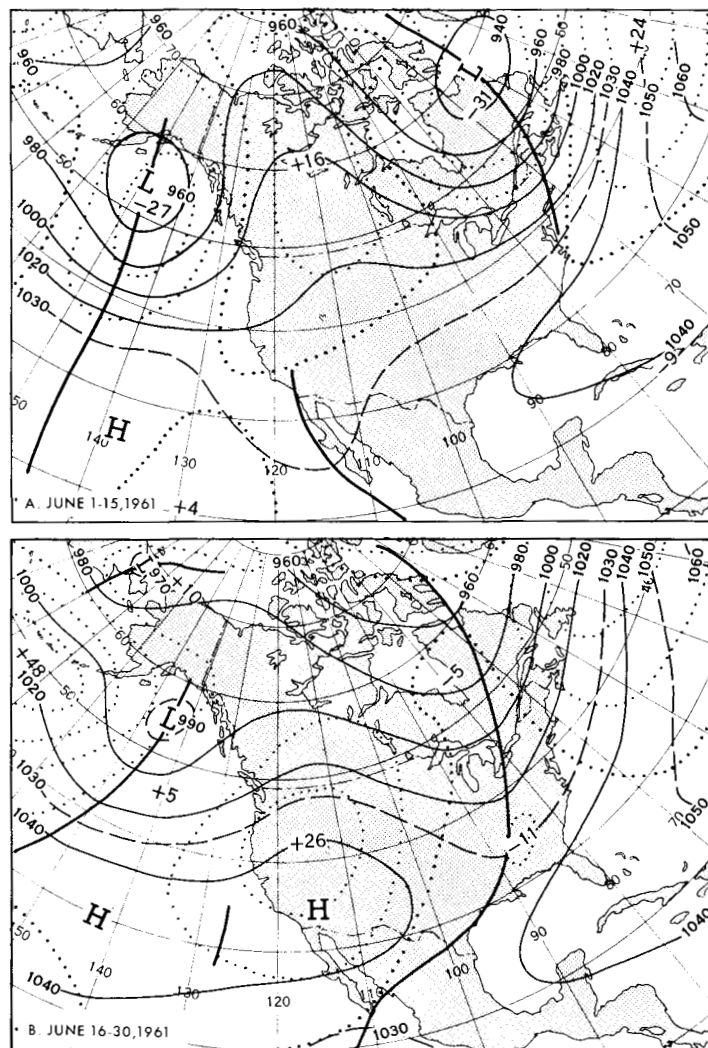


FIGURE 3.—Mean 700-mb. contours (solid) and departures from normal (dotted), both in tens of feet for (A) June 1–15, 1961, and (B) June 16–30, 1961. Retrogression of the trough in the East and intensification of the ridge in the West were important factors during June.

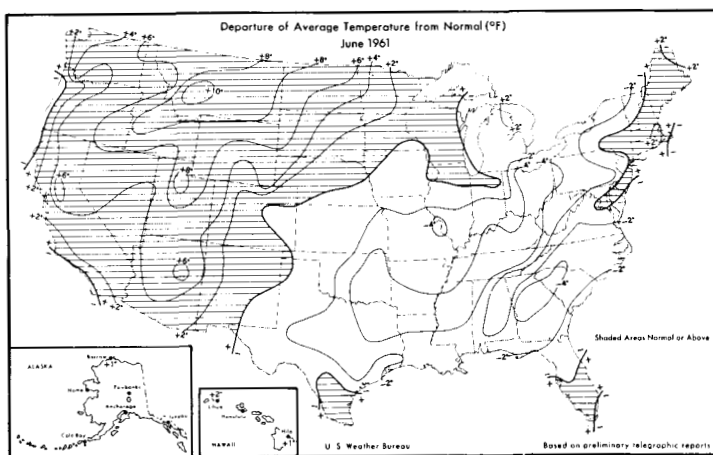


FIGURE 4.—Departure of average temperature from normal ( $^{\circ}\text{F.}$ ) for June 1961. Many new temperature records were established, especially in the West. (From [5].)

TABLE 1.—New monthly maximum temperature records in June 1961.

Location	Maximum temperature ( $^{\circ}\text{F.}$ )
San Francisco, Calif.	106
Bakersfield, Calif.	113
Medford, Oreg.	109
Pendleton, Oreg.	108
Winslow, Ariz.	105
Salt Lake City, Utah	104
Yakima, Wash.	103
Rapid City, S. Dak.	106

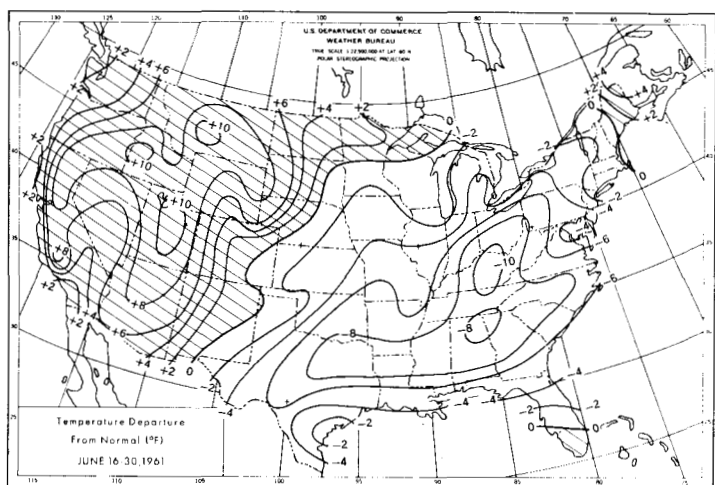
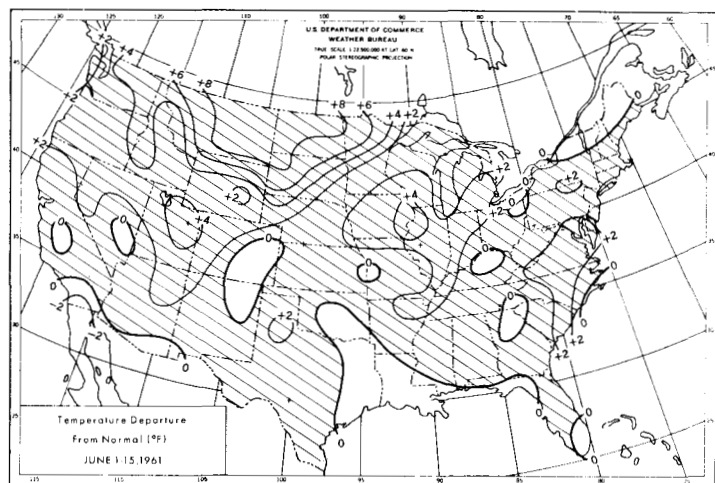


FIGURE 5.—Departure of average temperature from normal (°F.) for (A) June 1–15, 1961, and (B) June 16–30, 1961. Note that (B) most closely resembles figure 4.

Las Vegas, Nev., where the daily maximum temperature ranged from 110° to 113° F. from June 17 to 26. Most cities in Montana had the warmest June of record. Other spectacular records include new maximum temperatures for June as shown in table 1.

Above normal temperatures were not confined to the United States. The core of warm thickness and above normal heights extended northward to the Beaufort Sea. Reports from the Canadian Meteorological Branch, Department of Transport, indicate that temperatures exceeded normal by 6° to 8° F. from southern Alberta to Great Slave Lake and by more than 4° F. from there to 70° N.

Temperature anomalies discussed above can be examined less grossly by considering the 15-day averages (fig. 5). The large changes in the circulation (fig. 3) from the first half of June to the last half are clearly reflected in these temperature changes. Temperatures for June 1–15 (fig. 5A) were above normal over much of the United States. Maximum departures exceeded 8° F. in Montana and

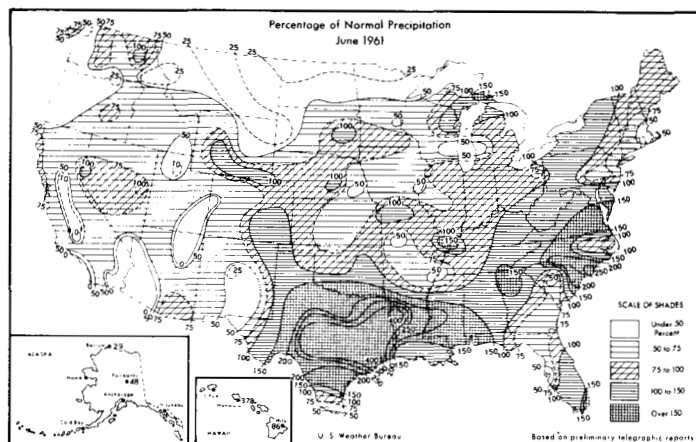


FIGURE 6.—Percentage of normal precipitation for June 1961. Only the South and parts of the East received more than normal rainfall. (From [5].)

North Dakota, the region in which positive height departures were largest (fig. 3A).

During the last half of June (fig. 5B) large-scale cooling in the East caused temperatures to decrease 6° to 10° F. from Texas to the Atlantic coast. In the West, influenced by the anticyclogenesis aloft (fig. 3B), the area of warmth expanded to the southern border and intensified by about 5° F. in most States.

Widespread warmth over western North America occurred when deepening in the Gulf of Alaska reinforced the ridge that normally lies along the Canadian Rockies. Consequently, there was little penetration of western North America by Pacific air masses as the average jet axis swept northward off the west coast instead of eastward along its usual path in middle latitudes. All aspects of the mean circulation that supported the heat in the West also favored a relatively dry month in this area.

#### PRECIPITATION

Quite dry conditions prevailed over most of the western half of the country (fig. 6), while precipitation was generally heavy in most of the South and in portions of the East.

Rainfall in the West was effectively inhibited by the 700-mb. flow (fig. 1). The anticyclone in the West and its associated ridge were sufficiently strong to present a barrier to the transport of moisture from the Pacific. In addition, the desiccating nature of anticyclonic conditions and the predominantly downslope direction of the anomalous flow contributed to the dry weather. There were few monthly records established in the West, but rainfall was appreciably below normal and contributed to prolonging a period of light precipitation in that region.

The average 700-mb. flow (fig. 1) was conducive to heavier than normal rainfall along and eastward from the trough in the central States. Features of the 700-mb. chart favoring heavy precipitation in Texas included the trailing trough, below normal heights, and easterly

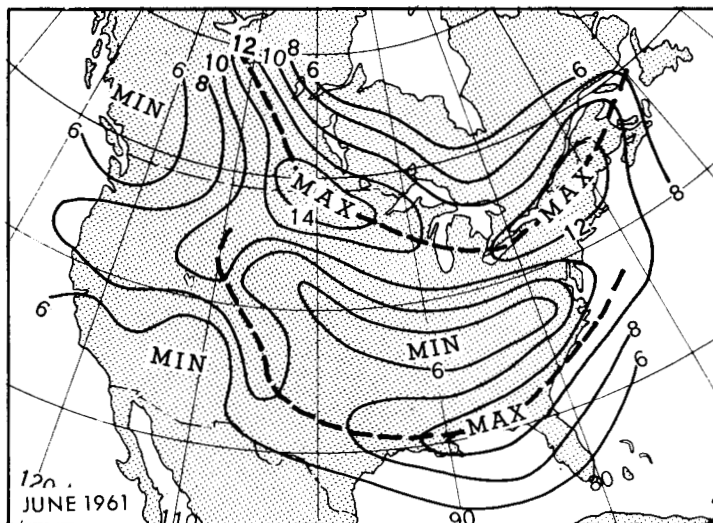


FIGURE 7.—Number of days with fronts in equal area (66,000 n. mi.<sup>2</sup>) quadrilaterals for June 1961. Heavy precipitation occurred along the axis of maximum frontal frequency in the South; in the North fronts were “drier” due to virtual exclusion of moisture from Gulf of Mexico by strong northerly flow.

anomalous wind components. In addition, temperatures were fairly cool (figs. 2 and 4) from the surface to 700 mb. and the influx of moisture at the surface (Chart XI of [3]) was moderately strong from the Gulf of Mexico to Oklahoma. Thus, conditions were optimum for overrunning and heavy precipitation in this area. Record amounts for June were observed at Waco and Abilene, Tex., and Shreveport, La.

The distribution of precipitation can also be considered as a function of frontal activity. Figure 7 shows an axis of maximum frontal frequency from Texas to southern Alabama to North Carolina. The location of this average frontal zone corresponds well to the area of heavy precipitation, as would be expected. However, the area of maximum frontal occurrence from North Dakota to the Lower Great Lakes shows a higher frequency than that in the South, yet the precipitation “fit” was relatively poor, except in New York and Pennsylvania. The flow at all levels west of the trough at 700 mb. contained a northerly component, carrying dry air into the country. Therefore, fronts in the West were ineffective in producing rain of any consequence, a major factor in the perpetuation of drought in this area.

#### DROUGHT

A significant shortage of precipitation in the last ten months has produced a drought of particular severity in portions of the States shown in figure 8A (from [5]). The 700-mb. mean circulation for most of the United States and Canada for the period September 1960 to June 1961 (fig. 8B) was prepared in order to detect any correspondence between the flow and the drought. Anomalous precipitation is not uniquely defined by mean 700-mb. contours, but there are components of this

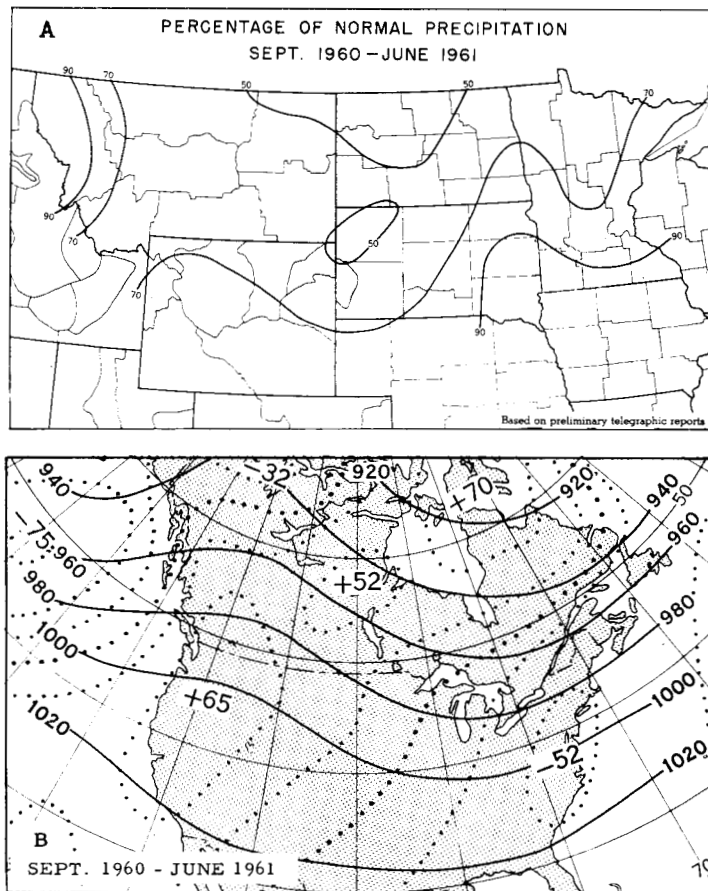


FIGURE 8.—(A) Percentage of normal precipitation (from [5]), and (B) mean 700-mb. contours (solid) in tens of feet and departures from normal (dotted) in 25-ft. intervals, with centers labeled in feet. Both for September 1960–June 1961.

circulation that seem to augment or inhibit the production of precipitation. In this instance the flow itself implies little and, in fact, resembles grossly the normal circulation that consists of a ridge over the western mountains and a trough over eastern North America. However, the dotted isopleths in figure 8B representing the anomalous components of the 700-mb. heights clarify the situation. Note, first, that heights were all above normal in the drought area, and, second, that the direction of anomalous flow was northerly. Although both conditions favor dry weather, the latter is most frequently associated with a deficiency of precipitation on mean circulations.

It would be an over-simplification to attempt to explain the drought solely in terms of the anomalous 700-mb. flow, but there was a significant contribution. Statistical evidence [6] indicates that winter precipitation in North Dakota is negatively correlated with 700-mb. heights in southern Idaho and positively correlated with heights in the Middle Atlantic States (both correlation coefficients exceed 0.5). It follows that anomalous northerly flow components of the type portrayed in figure 8B should be associated with a dry regime in the Dakotas.



## REFERENCES

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2. R. H. Gelhard, "The Weather and Circulation of May 1961—Persistent Cool Weather in the United States," *Monthly Weather Review*, vol. 89, No. 8, Aug. 1961, pp. 299–305.
3. U.S. Weather Bureau, *Climatological Data—National Summary*, vol. 12, No. 6, June 1961, Charts IX and X.
4. W. H. Klein, "Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere," U.S. Weather Bureau, *Research Paper No. 40*, Washington, D.C., 1957, 60 pp.
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## Weather Bureau Technical News

## ISOTOPE-POWERED AUTOMATIC WEATHER STATION

The latest development in the automatic observation of weather is the incorporation of a radio-isotope power plant into the apparatus of automatic stations. This allows unattended operation of the station up to the limit of instrument life and eliminates the difficulties met with in other automatic stations from lack of a continuous power source. The first such station was set up in August on or near Graham Island in the Canadian Arctic about halfway between the Joint Canadian-United States Arctic Weather Stations at Eureka and Resolute. Power is generated by the heat spontaneously produced by radio active decay of pellets of strontium-90, in the form of strontium titanate, enclosed in a small (5-inch) shielded cylindrical capsule. The heat is transformed directly into a continuous flow of electricity by 60 pairs of thermocouples arranged like spokes around the cylindrical heat source. The whole generator is shielded in 4.4 inches of lead and covered by an outer skin of stainless steel. The overall dimensions are 20 inches long by 18 inches in diameter.

The generator cylinder is the bottom element in a larger cylindrical container 8 feet long. The top compartments of this house the electrical apparatus, recording equipment, radio transmitters, and the barometer. Excess heat from the generator serves to maintain an interior operating temperature of 70° F. The anemometer and thermometer are exposed on a mast beside the cylinder, the lower 5 feet of which is buried in the ground.

Observations of wind direction (to nearest 10° heading), wind speed (0 to 150 kt.  $\pm 1$  kt., 1 and 8 minute average), pressure (28.00 to 32.00 in.,  $\pm 0.02$  in.), and temperature (–75° to +120° F.,  $\pm 1^\circ$  F.) is transmitted by radio in 8 bit binary digital form once every 3 hours simultaneously on two frequencies, 3.36 and 4.97 megacycles. The transmitter output is 250 watts on each frequency with range up to 1500 miles depending on the frequency. The transmission consists of call letters and data measurements plus one repeat. Provision has been made in the package for

measuring other elements such as precipitation, humidity, sky cover, etc., whenever suitable sensors become available.

The measuring and transmitting equipment are designed and fabricated to provide reliability consistent with the long life of the isotope, to use a minimum of electricity, and to produce accurate weather data in usable form. Since the generator sustains no wear from moving parts, long-term maintenance-free operation is possible. The generator could power the station for more than ten years.

Although these stations will always be located in remote or completely uninhabited areas such as the present site, great care was taken in the development of a safe fuel form and adequate, reliable shielding. Strontium becomes a biological problem only if it is absorbed by some living organism. This danger can be eliminated by using an insoluble compound. To provide at the same time a fuel material dense enough to conserve space and relatively easy to produce, strontium titanate was selected. This compound remains stable even beyond its melting point of 3000° F., and its rate of solubility in fresh water is so low it has not been measured. In salt water its solubility is measured in parts per billion. The shielding within the generator consists of several layers of an alloy called Hastelloy-C. It would take centuries to corrode, even if immersed in sea water. The outside shielding of the generator cylinder is  $\frac{3}{4}$  ton of lead with a final covering of stainless steel. The whole generator is designed so sturdily that it could survive a plane crash or an explosion without releasing its fuel.

The station was designed and built by the nuclear division of the Martin Company, Baltimore, Md., under a contract with the U.S. Atomic Energy Commission, Office of Isotopes Development in cooperation with the U.S. Weather Bureau. The site was suggested by the Department of Transport of Canada and the station was installed by a joint Canadian and United States work party.